

WHAT IS CLAIMED IS

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1. A multi-beam scanning device, scanning a to-be-scanned surface with a plurality of laser beams simultaneously, comprising:

10 a light-source unit comprising a plurality of laser arrays, each comprising a plurality of light-emitting points, a corresponding plurality of coupling lenses coupling laser beams emitted from said plurality of laser arrays, respectively and a holding member integrally holding said plurality of laser arrays and  
15 plurality of coupling lenses rotatably approximately about optical axes of said laser arrays; and

a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging them onto the to-be-scanned surface,

20 wherein said light-source unit and scanning optical system are configured so that the following equation be satisfied:

$$\begin{aligned} AY &= |q \times \cos \phi \times mY \times (n-1) / \\ 25 \quad (2 \times f_{col} \times \tan \theta \times \cos \gamma \times mZ)| &\leq 0.1 \end{aligned}$$

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n denotes the number of light-emitting points on each laser array;

q denotes an interval between each adjacent ones of the light-emitting points on each laser array;

$\phi$  denotes an inclination angle of each laser array with respect to a sub-scanning direction;

mY denotes a magnification of said scanning optical system on main scanning direction;

mZ denotes a magnification of said scanning optical system on sub-scanning direction;

fcol denotes the focal length of each coupling lens;

$\theta$  denotes half a crossing angle at which the laser beams emitted from said plurality of laser arrays cross therebetween;

$\gamma$  denotes a maximum required rotational angle of said light-source unit in case of adjustment.

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2. A multi-beam scanning device, scanning a  
to-be-scanned surface with a plurality of laser beams  
25 simultaneously, comprising:

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a light-source unit comprising a plurality of laser arrays, each comprising a plurality of light-emitting points, a corresponding plurality of coupling lenses coupling laser beams emitted from said plurality of laser arrays, and a holding member integrally holding said plurality of laser arrays and plurality of coupling lenses rotatably approximately about optical axes of said laser arrays; and

a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging them onto the to-be-scanned surface,

wherein said light-source unit and scanning optical system are configured so that the following equation be satisfied:

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$$AZ = |q \times \sin \phi \times (n-1) / (2 \times f_{col} \times \tan \theta \times \cos \gamma)| \leq 0.1$$

where:

20         $n$  denotes the number of light-emitting points on each laser array;

$q$  denotes an interval between each adjacent ones of the light-emitting points on each laser array;

$\phi$  denotes an inclination angle of each laser array with respect to a sub-scanning direction;

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fc<sub>ol</sub> denotes the focal length of each coupling lens;

$\theta$  denotes half a crossing angle at which the laser beams emitted from said plurality of laser arrays cross therebetween; and

$\gamma$  denotes a maximum required rotational angle of said light-emitting unit in case of adjustment.

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3. The multi-beam scanning device as claimed in claim 1, wherein the number of laser arrays on said light-source unit is two.

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4. The multi-beam scanning device as claimed in claim 2, wherein the number of laser arrays on said light-source unit is two.

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5. The multi-beam scanning device as claimed in claim 1, wherein the inclination angle of each laser array can be adjusted individually.

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6. The multi-beam scanning device as claimed in claim 2, wherein the inclination angle of each laser array can be adjusted individually.

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7. The multi-beam scanning device as claimed in claim 1, wherein each laser array is rotatably held by said holding member.

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8. The multi-beam scanning device as claimed in claim 2, wherein each laser array is rotatably held by said holding member.

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9. The multi-beam scanning device as claimed  
in claim 1, wherein said light-source unit and scanning  
optical system are configured such that a ratio A0  
between a main-scanning-directional component and a sub-  
5 scanning-direction component of a change in beam-spot  
interval on the to-be-scanned surface occurring  
according to change in the inclination angle of each  
laser array satisfies the following equation:

10 
$$1/3 \leq A0 \leq 3$$

where

15 
$$A0 = |(mY/mZ) \times \tan \phi|$$

Where:

mY denotes a magnification of said scanning  
optical system on main scanning direction; and

mZ denotes a magnification of said scanning  
20 optical system on sub-scanning direction.

25 10. The multi-beam scanning device as claimed

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in claim 2, wherein said light-source unit and scanning optical system are configured such that a ratio  $A_0$  between a main-scanning-directional component and a sub-scanning-direction component of a change in beam-spot interval on the to-be-scanned surface occurring according to change in the inclination angle of each laser array satisfies the following equation:

$$1/3 \leq A_0 \leq 3$$

where

$$A_0 = |(mY/mZ) \times \tan \phi|$$

Where:

$mY$  denotes a magnification of said scanning optical system on main scanning direction; and

$mZ$  denotes a magnification of said scanning optical system on sub-scanning direction.

11. A multi-beam scanning device, scanning a to-be-scanned surface with a plurality of laser beams

simultaneously, comprising:

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- 5 a light-source unit comprising a plurality of laser arrays, each comprising a plurality of light-emitting points, a corresponding plurality of coupling lenses coupling laser beams emitted from said plurality of laser arrays, respectively, and a holding member integrally holding said plurality of laser arrays and plurality of coupling lenses rotatably approximately about optical axes of said laser arrays;
- 10 a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging them onto the to-be-scanned surface; and
- 15 a part switching a scanning density on the to-be-scanned surface by rotating said light-source unit approximately about the optical axes of said laser arrays.

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12. The multi-beam scanning unit as claimed in claim 11, further comprising a detecting part detecting a synchronization signal for determining a scanning start timing,

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wherein:



said detecting part obtains the synchronization signal from a laser beam emitted from one of the light-emitting points of each of the laser arrays; and

5 scanning start timings on the other light-emitting points are determined as a result of shifting by specific delay times from the synchronization signal thus obtained.

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13. The multi-beam scanning device as claimed in claim 11, wherein the number of the laser arrays  
15 provided is two.

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14. The multi-beam scanning device as claimed in claim 11, wherein said light-source unit and scanning optical system are configured so that the following formula be satisfied:

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$$\Delta RY = \left| \{ (n-1) \times (2n-1) / 2 \} \times \right. \\ \left. \{ (q \times \cos \phi \times mY \times d) / (fcol \times \tan \theta \times mZ) \} \right| \leq d/4$$

where:

5                   d denotes a scanning line interval on the to-be-scanned surface;

                  n denotes the number of light-emitting points on each laser array;

                  q denotes an interval between each adjacent  
10 ones of the light-emitting points on each laser array;

$\phi$  denotes an inclination angle of each laser array with respect to a sub-scanning direction;

                  mY denotes a magnification of said scanning optical system on main scanning direction;

15                   mZ denotes a magnification of said scanning optical system on sub-scanning direction;

                  fcol denotes the focal length of each coupling lens;

$\theta$  denotes half a crossing angle at which the  
20 laser beams emitted from said plurality of laser arrays cross therebetween; and

$\Delta RY$  denotes the main-scanning-directional component of beam-spot interval between both ends of beam spots on the to-be-scanned surface for each laser  
25 array.

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15. The multi-beam scanning device as claimed in claim 11, wherein said light-source unit and scanning optical system are configured so that the following formula be satisfied:

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$$\Delta RZ = \left| \left\{ (n-1) \times (2n-1) / 2 \right\} \times \right. \\ \left. \left\{ (q \times \sin \phi \times d) / (fcol \times \tan \theta) \right\} \right| \leq d/4$$

where:

d denotes a scanning line interval on the to-be-scanned surface;

n denotes the number of light-emitting points on each laser array;

q denotes an interval between each adjacent ones of the light-emitting points on each laser array;

$\phi$  denotes an inclination angle of each laser array with respect to a sub-scanning direction;

fcol denotes the focal length of each coupling lens;

$\theta$  denotes half a crossing angle at which the laser beams emitted from said plurality of laser arrays cross therebetween; and

$\Delta RZ$  denotes the sub-scanning-directional component of beam-spot interval between both ends of beam spots on the to-be-scanned surface for each laser array.

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16. The multi-beam scanning device as claimed  
in claim 11, wherein delay times applied on the  
respective beam spots for scanning start timing are  
determined such that scanning start timing is optimum in  
5 case where a higher scanning density is applied through  
said switching part.

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17. The multi-beam scanning device as claimed  
in claim 11, wherein delay times applied on the  
respective beam spots for scanning start timing are  
variable according to the scanning density switched.

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18. An image formation apparatus comprising  
20 the multi-beam scanning device as claimed in claim 1.

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19. An image formation apparatus comprising

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the multi-beam scanning device as claimed in claim 2.

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20. An image formation apparatus comprising  
the multi-beam scanning device as claimed in claim 11.

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21. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and  
15 the multi-beam scanning device claimed in  
claim 1 scanning at least one of said to-be-scanned  
surfaces.

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22. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and  
25 the multi-beam scanning device claimed in

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claim 2 scanning at least one of said to-be-scanned surfaces.

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23. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and

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the multi-beam scanning device claimed in  
claim 11 scanning at least one of said to-be-scanned  
surfaces.

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24. A multi-beam scanning device, scanning a  
to-be-scanned surface with a plurality of laser beams  
simultaneously, comprising:

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light-source unit comprising a plurality of  
laser means, each comprising a plurality of light-  
emitting points, a corresponding plurality of coupling  
means for coupling laser beams emitted from said

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plurality of laser arrays, and a holding means for  
integrally holding said plurality of laser means and

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plurality of coupling means rotatably approximately about optical axes on the laser means; and

a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging

5 them onto the to-be-scanned surface,

wherein said light-source unit and scanning optical system are configured so that the following equation be satisfied:

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$$AY = |q \times \cos \phi \times mY \times (n-1) /$$
$$(2 \times fcol \times \tan \theta \times \cos \gamma \times mZ)| \leq 0.1$$

where:

n denotes the number of light-emitting points on each laser means;

15 q denotes an interval between each adjacent ones of the light-emitting points on each laser means;

$\phi$  denotes an inclination angle of each laser means with respect to a sub-scanning direction;

mY denotes a magnification of said scanning optical system on main scanning direction;

20 mZ denotes a magnification of said scanning optical system on sub-scanning direction;

fcol denotes the focal length of each coupling means;

25  $\theta$  denotes half a crossing angle at which the

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laser beams emitted from said plurality of laser means cross therebetween; and

$\gamma$  denotes a maximum required rotational angle of said light-emitting unit in case of adjustment.

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25. A multi-beam scanning device, scanning a  
10 to-be-scanned surface with a plurality of laser beams simultaneously, comprising:

a light-source unit comprising a plurality of  
laser means, each comprising a plurality of light-  
emitting points, a corresponding plurality of coupling  
15 means for coupling laser beams emitted from said plurality of laser means, and holding means for integrally holding said plurality of laser means and plurality of coupling means rotatably approximately about optical axes on the laser means; and

20 a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging them onto the to-be-scanned surface,

wherein said light-source unit and scanning optical system are configured so that the following  
25 equation be satisfied:

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$$AZ = |q \times \sin \phi \times (n-1) / \\ (2 \times f_{col} \times \tan \theta \times \cos \gamma)| \leq 0.1$$

where:

5           n denotes the number of light-emitting points  
on each laser means;

          q denotes an interval between each adjacent  
ones of the light-emitting points on each laser means;

$\phi$  denotes an inclination angle of each laser  
10 means with respect to a sub-scanning direction;

$f_{col}$  denotes the focal length of each coupling  
means;

$\theta$  denotes half a crossing angle at which the  
laser beams emitted from said plurality of laser means  
15 cross therebetween; and

$\gamma$  denotes a maximum required rotational angle  
of said light-source unit in case of adjustment.

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26. The multi-beam scanning device as claimed  
in claim 24, wherein the number of laser means on said  
light-source unit is two.

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27. The multi-beam scanning device as claimed  
in claim 25, wherein the number of laser means on said  
light-source unit is two.

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28. The multi-beam scanning device as claimed  
in claim 24, wherein the inclination angle of each laser  
10 means can be adjusted individually.

15 29. The multi-beam scanning device as claimed  
in claim 25, wherein the inclination angle of each laser  
means can be adjusted individually.

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30. The multi-beam scanning device as claimed  
in claim 24, wherein each laser means is rotatably held  
by said holding means.

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31. The multi-beam scanning device as claimed in claim 25, wherein each laser means is rotatably held by said holding means.

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32. The multi-beam scanning device as claimed in claim 24, wherein said light-source unit and scanning optical system are configured such that a ratio A0  
10 between a main-scanning-directional component and a sub-scanning-direction component of a change in beam-spot interval on the to-be-scanned surface occurring according to change in the inclination angle of each  
15 laser means satisfies the following equation:

$$1/3 \leq A0 \leq 3$$

where

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$$A0 = |(mY/mZ) \times \tan \phi|$$

where:

mY denotes a magnification of said scanning  
25 optical system on main scanning direction; and

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mZ denotes a magnification of said scanning optical system on sub-scanning direction.

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33. The multi-beam scanning device as claimed in claim 25, wherein said light-source unit and scanning optical system are configured such that a ratio A0  
10 between a main-scanning-directional component and a sub-scanning-direction component of a change in beam-spot interval on the to-be-scanned surface occurring according to change in the inclination angle of each laser means satisfies the following equation;

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$$1/3 \leq A0 \leq 3$$

where

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$$A0 = |(mY/mZ) \times \tan \phi|$$

Where:

mY denotes a magnification of said scanning optical system on main scanning direction; and

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mZ denotes a magnification of said scanning

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optical system on sub-scanning direction.

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34. A multi-beam scanning device, scanning a to-be-scanned surface with a plurality of laser beams simultaneously, comprising:

10 a light-source unit comprising a plurality of laser means, each comprising a plurality of light-emitting points, a corresponding plurality of coupling means coupling laser beams emitted from said plurality of laser means, and holding means integrally holding said plurality of laser means and plurality of coupling  
15 means rotatably approximately about optical axes on the laser means;

a scanning optical system deflecting the laser beams emitted from said light-source unit and imaging them onto the to-be-scanned surface; and

20 means for switching a scanning density on the to-be-scanned surface by rotating said light-source unit approximately about the optical axes of the laser means.

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35. The multi-beam scanning unit as claimed in claim 34, further comprising detecting means for detecting a synchronization signal for determining a scanning start timing,

5                wherein:

              said detecting means obtains the synchronization signal from a laser beam emitted from one of the light-emitting points of each laser means; and

10               scanning start timings on the other light-emitting points are determined as a result of shifting by specific delay times from the synchronization signal thus obtained.

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36. The multi-beam scanning device as claimed in claim 34, wherein the number of laser means provided  
20    is two.

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37. The multi-beam scanning device as claimed

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in claim 34, wherein said light-source unit and scanning optical system are configured so that the following formula be satisfied:

$$\Delta RY = \left| \left\{ (n-1) \times (2n-1) / 2 \right\} \times \right. \\ \left. \left\{ (q \times \cos \phi \times mY \times d) / (fcol \times \tan \theta \times mZ) \right\} \right| \leq d/4$$

where:

- d denotes a scanning line interval on the to-be-scanned surface;
- n denotes the number of light-emitting points on each laser means;
- q denotes an interval between each adjacent ones of the light-emitting points on each laser means;
- $\phi$  denotes an inclination angle of each laser means with respect to a sub-scanning direction;
- mY denotes a magnification of said scanning optical system on main scanning direction;
- mZ denotes a magnification of said scanning optical system on sub-scanning direction;
- fcol denotes the focal length of each coupling means;
- $\theta$  denotes half a crossing angle at which the laser beams emitted from said plurality of laser means cross therebetween; and

$\Delta RY$  denotes the main-scanning-directional component of beam-spot interval between both ends of beam spots on the to-be-scanned surface for each laser means.

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38. The multi-beam scanning device as claimed  
10 in claim 34, wherein said light-source unit and scanning optical system are configured so that the following formula be satisfied:

$$\Delta RZ = \left| \{ (n-1) \times (2n-1) / 2 \} \times \right.$$

15  $\left. \{ (q \times \sin \phi \times d) / (f_{col} \times \tan \theta) \} \right| \leq d/4$

where:

$d$  denotes a scanning line interval on the to-be-scanned surface;

$n$  denotes the number of light-emitting points  
20 on each laser means;

$q$  denotes an interval between each adjacent ones of the light-emitting points on each laser means;

$\phi$  denotes an inclination angle of each laser means with respect to a sub-scanning direction;

25  $mZ$  denotes a magnification of said scanning

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optical system on sub-scanning direction;

$f_{col}$  denotes the focal length of each coupling means;

$\theta$  denotes half a crossing angle at which the  
5 laser beams emitted from said plurality of laser means cross therebetween; and

$\Delta RZ$  denotes the sub-scanning-directional component of beam-spot interval between both ends of beam spots on the to-be-scanned surface from each laser  
10 means.

15 39. The multi-beam scanning device as claimed in claim 34, wherein delay times applied on the respective beam spots for scanning start timing are determined such that scanning start timing is optimum in case where a higher scanning density is applied through  
20 said switching part.

25 40. The multi-beam scanning device as claimed

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in claim 34, wherein delay times applied on the  
respective beam spots for scanning start timing are  
variable according to the scanning density switched.

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41. An image formation apparatus comprising  
the multi-beam scanning device as claimed in claim 24.

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42. An image formation apparatus comprising  
the multi-beam scanning device as claimed in claim 25.

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43. An image formation apparatus comprising  
the multi-beam scanning device as claimed in claim 34.

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44. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and  
the multi-beam scanning device claimed in  
claim 24 scanning at least one of said to-be-scanned  
surfaces.

45. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and  
the multi-beam scanning device claimed in  
claim 25 scanning at least one of said to-be-scanned  
surfaces.

46. An image formation apparatus comprising:  
a plurality of photoconductor members to  
provide to-be-scanned surfaces; and  
the multi-beam scanning device claimed in  
claim 34 scanning at least one of said to-be-scanned

surfaces.

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